AD-A258 067

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

...to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, ...reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this ...burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson ...Office of Management and Budget, Paperwork Reduction Project ...

2. REPORT DATE: 09/17/91

3. REPORT TYPE AND DATES COVERED: Final Oct. 1,1988 - Sept.1, 1991

4. TITLE AND SUBTITLE

Sediment Flux, East Greenland Margin

5. FUNDING NUMBERS

2

6. AUTHOR(S)

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8. PERFORMING ORGANIZATION REPORT NUMBER

1530705

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Dept. of Defense, Office of Naval Research
800 N. Quincy St., Ballfston Towers, No. 1
Arling ton, Virginia 22217-5000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

N0001489-J-1013

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

We investigated sediment flux across an ice-dominated, high latitude continental margin, using cores from the East Greenland Shelf (ca. 68° N). Density, weight percentages of the various sediment components, and sediment/age relations (AMS C-14 dates) were investigated from cores collected 1988 and 1990. High-resolution DTS Huntec surveys indicated 10-20 m of acoustically transparant sediment. Maximum core length was 3 m and most of the gravity cores were between 1-2 m. The radiocarbon assays show that basal core sediments date between ca. 9,000 and 14,500 BP.

The acoustic characteristics, the low dry volume densities (ca. 600 kg/m^3), and the faunal and floral assemblages suggest ice-distal conditions between ca. 14,500 and the present. Net sediment flux in the Kangerdlugssuaq Trough during the last 14,500 years has been low; this might be explained by either i) cold-based glaciological conditions of the East Greenland ice sheet; and/or ii) efficient sediment trap(s) lying along the inner shelf/fjords of East Greenland.

14. SUBJECT TERMS

15. NUMBER OF PAGES: 17

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT

18. SECURITY CLASSIFICATION OF THIS PAGE

19. SECURITY CLASSIFICATION OF ABSTRACT

20. LIMITATION OF ABSTRACT

NSN 7540-01-280-5500

Standard Form 298 (Rev 2-89) Prescribed by ANSI Std 239-18 298-102

~~91 9 26 086~~

92-30569

92 12 01 022

FINAL REPORT TO OFFICE OF NAVAL RESEARCH

GRANT NO: ONRN0001489JI013

"*SEDIMENT FLUX, EAST GREENLAND MARGIN*"

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SUMMARY

We investigated sediment flux across an ice-dominated, high latitude continental margin using cores from the East Greenland Shelf (ca. 68° N). Density, weight percentages of the various sediment components, and sediment/age relations (AMS C-14 dates) were investigated from cores collected 1988 and 1990. High-resolution DTS Huntec surveys indicated 10-20 m of acoustically transparant sediment. Maximum core length was 3 m and most of the gravity cores were between 1-2 m. The radiocarbon assays show that basal core sediments date between ca. 9,000 and 14,500 BP.

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INTRODUCTION

There have been few systematic efforts to measure the net flux of sediment to the seafloor along high-latitude continental margins. However, to understand several issues of importance in marine geology, such information is vital. Issues such as ice sheet to deep-sea sediment transfers, ice sheet/ocean interactions, biological productivity of high-latitude seas, seafloor morphology, and acoustic properties of sediments all have some relationship to the question of net seafloor sediment fluxes.

With support from ONR we have investigated net sediment fluxes along two distinct high-latitude margins. At first we examined data from the fiords and shelf of Baffin Island, N.W.T., Canada, a margin that experienced massive ice sheet disintegration between 7-12 ka and where currently only small glaciers and ice caps exist. With support from the present ONR grant we next investigated an area off the East Greenland margin where the world's second largest ice sheet still exists and where information on the extent of glaciation on the shelf was essentially lacking (Funder, 1989).

Publications from the first area, eastern Baffin Island, N.W.T., have been largely completed (Andrews, 1990; Andrews, Geirsdottir, & Jennings, 1989; Andrews, & Jennings, 1990) and in one paper (Andrews, & Syvistki, 1991), we have compared the net sediment fluxes between the two areas. A preliminary paper on the East Greenland data has been accepted for publication (Mienert, Andrews, & Milliman, in press) and the INSTAAR group is currently working on a detailed analysis of the data (cf. Andrews, Williams, Milliman, & Weiner, 1989; Andrews et al., in prep; Williams, in prep).

BACKGROUND

Kangerdlugssuaq Fiord is deeply incised into the mountainous coast of East Greenland. A major channel, the Kangerdlugssuaq Trough, cuts across the shelf from the mouth of the fjord to the upper continental slope (Fig. 1). Water depths in the trough are 400-600 m.

At water depths $\leq$ 300 m the shelf is moderately scoured by icebergs. The presence of strong currents plus the action of ice berg scour, restrict accumulation of sediments on the shelf proper. However, relatively thick sediment has accumulated on the floor of the trough. The acoustic properties of the uppermost 10-20 m of sediment is analagous to the upper "postglacial" unit that is typical of the late Quaternary marine succession along the entire length of the northeastern Canadian margin (Andrews, et al., 1991; Josenhans, Zevenhuizen, & Klassen, 1986; MacLean, 1985; MacLean, et al., 1989; Praeg, MacLean, Hardy, & Mudie, 1986). The uppermost unit along the southern Baffin Island shelf (northeastern Canadian margin) is acoustically transparent and overlies a strongly stratified acoustic unit which is coeval with regional deglaciation (Jennings, 1989).

The WHOI giant gravity corer (10 cm diameter) penetrated the uppermost 1-2 m of the sediment (Mienert, et al., in press), hence by analogy with our Canadian experience, we expected that these sediments would date from the middle to late Holocene.

RESULTS

Most cores contained sufficient foraminifera, and we could pick 1-5 mg of calcareous taxa for accelerator mass spectrometry (AMS) dates. We used the University of Arizona's NSF National Facility (Linick, Jull, Toolin, & Donahue, 1986; Slota, Jull, Linick, & Toolin, 1987). We have obtained 16 dates from the 1988 *Bjarni Saedmundson* cruise, and three from the 1990 *Poseidon* cruise. One date from the 1990 cruise that is still outstanding. Table 1 lists the core locations and Table 2 details the results of the ^{14}C analyses.

The results of the dating program indicate that the accumulation of sediment (i.e. L/T, where L=thickness and T=time) on the floor of the Kangerdlugssuaq Trough is slow, much slower than in troughs along the northeastern Canadian margin (Andrews, et al., 1991; Andrews, et al., 1991). Radiocarbon dating of sediment at core tops suggests that sedimentation has been continuous during the late Holocene.

Measurements of the dry volume density of cores within the trough indicated that sediment density was relatively low (Fig. 2). This result, in combination with the low rates of sediment accumulation, indicates that mass sediment accumulation (M/AT where A= area and M=mass) is low, averaging only 60 kg/m^2 ka during the Holocene (Andrews, et al., 1991) compared to around 500 kg/m^2 ka for some northeastern Canadian troughs (Andrews, 1987). There are several possible explanations for this low mass sediment accumulation, including:

1) Little sediment is being produced at the base of the East Greenland Ice Sheet because it is frozen to its bed over much of its area; and/or

2) Little sediment is escaping from the ice sheet because it is trapped in intermediate to proximal basins in fiords and along the inner shelf.

The sediment that is accumulating on the seafloor consists of water-and-ice transported mineral matter, biogenic silica, biogenic carbonate, and organic carbon. The sources for these materials consist of sediment transported in glacial meltwater plumes, material rafted and released at the site in icebergs and sea ice, resuspended sediments (caused by current winnowing and by iceberg contact with the seafloor), and possibly debris and turbitity flows, plus biogenic components.

With the completion of the dating program (last dates reported in the summer, 1991) we are now in a position of being able to compute mass sediment accumulation rates and to partition the sediment into its various components on the basis of i) rates of sediment accumulation; ii) dry volume density measurements; and iii) weight percentage data. These data will be presented in two papers currently in progress (Williams, in prep; Andrews et al., in prep.).

Biogenic silica content of the cores was analyzed, using a technique developed by Mortlock and Froelich (Mortlock, 1989). Biogenic silica (opal) along the east Greenland coast consists mainly of diatom frustules with a minor component of radiolarians and silicoflagellates, except in the top 40 cm in core 5A and the top 10 cm in core 10 A, where layers of sponge spicules are prominent.

The amount of opal present in the cores can be used as a proxy technique to interprete paleo-productivity over the core sites. The interpretation in turn can be used to trace surface water distribution changes and observe past changes in intensity of the East Greenland Current , as well as to determine the timing of withdrawal of permanent ice from the area (Williams, in prep.).

Two cores were analyzed with this technique, cores 10 A and

5A. The results show that total calcite and total opal are in present in approximately the same proportions (Fig. 3). Conventional wisdom has held that calcite is predominant in northern high latitudes, with very little opal present. Yet, here exist areas were this does not hold true. In fact, in several samples, opal is present in higher amounts than calcite. It is likely that, upon further investigation, opal will be found to be more prevalent in sediments from high northern latitudes than previously thought.

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Table 1. Core locations, core length and water depth for cores collected 1988.

Core	Location	Core length (cm)	Depth (m)
	East-Greenland Margin		
8	66°27.53'N 29°41.09'W	49	299
10	66°12.19'N 30°39.29'W	128	496
3	67°24.59'N 31°03.98'W	142	624
13	65°24.68'N 30°51.34'W	42.5	643
6	67°04.72'N 30°53.62'W	209	668
7	67°05.26'N 30°52.32'W	185	688
5	67°07.54'N 30°54.26'W	154	707
18	65°22.53'N 30°27.18'W	61	796
17	65°19.15'N 30°59.68'W	86	999
	Denmark Strait		
V29-206	64°54.34'N 29°17.37'W	1080	1608
V28-14	64°47.00'N 29°34.00'W	611	1855

Table 1,(continued) Cores collected 1990.

Datum	Zeit (GMT)	Stations-Nr. PO-175/1	Länge	Breite	Wasser-tiefe (m)	Gerät	Gewinn (cm)	Profil Nr.
Strede-Bank								
17.10.90	01:32	1-1	29°40.05W	66°17.11N	321	GKG	20	6
		1-2				KAL	- -	
		1-3				KAL	- -	
17.10.90	05:03	2-1	29°40.07W	66°28.02N	313	KAL	40	7
17.10.90	06:25	3-1	29°37.88W	66°37.86N	302	KAL	30	8
17.10.90	09:00	4-1	29°44.98W	66°56.79N	279	GKG	33	9
Kangerdlugssuaq-Kanal								
17.10.90	12:41	5-1	30°50.42W	66°45.83N	505	KAL	295	10
		6-1				KAL	- -	
		6-2				KAL	- -	
17.10.90	15:59	6-3	30°50.18W	66°37.06N	502	GKG	25	11
17.10.90	17:37	7-1	30°50.11W	66°27.10N	450	GKG	23	12
17.10.90	18:20	7-2	30°50.11W	66°27.10N	447	KAL	137	12
Bank östl. des Kangerdlugssuaq-Kanals								
17.10.90	21:52	8-1	31°59.86W	66°13.04N	292	GKG	18	13
17.10.90	22:47	9-1	32°00.16W	66°09.17N	288	GKG	20	14
Äußerer Schelf und Kontinentalhang								
18.10.90	02:32	10-1	31°00.06W	65°48.04N	407	GKG	20	15
18.10.90	03:33	10-2	31°00.06W	65°48.04N	406	KAL	60	15
18.10.90	06:36	11-1	30°50.87W	65°30.21N	401	KAL	8	16
18.10.90	08:16	12-1	30°50.31W	65°26.76N	477	GKG	15	17
18.10.90	09:00	12-2	30°50.31W	65°26.76N	487	GKG	20	17
18.10.90	10:40	13-1	30°49.36W	65°19.20N	1020	GKG	- -	18
		13-2				KAL	- -	
18.10.90	19:07	14-1	30°01.92W	65°29.70N	423	GKG	10	19
18.10.90	23:51	15-1	30°50.06W	65°09.27N	1554	GKG	28	20
19.10.90	20:24	16-1	29°26.63W	65°41.70N	424	GKG	1	
20.10.90	00:37	17-1	28°48.05W	65°34.12N	1156	KAL	- -	

GKG = Großkastengreifer, KAL = Kastenlot

Station 175/1-15 wurde unter extremen Seegangsverhältnissen abgearbeitet. Aus Sicherheitsgründen mußten weitere Stationen auf den nächsten Tag verlegt werden. Am 19.10.90 machten schwere See und Windstärken > 9 Beaufort Stationsarbeiten unmöglich. Der Sturm mußte abgewartet werden. Im Laufe des Abends flaute der Sturm merklich ab, so daß in der Nacht weitergearbeitet werden konnte. Der GKG Einsatz bereitete jedoch Probleme, da sich einige bewegliche Teile vermutlich durch die über das Deck hereinbrechenden Wellen verzogen hatten.

Table 2. C-14 dates.

Core ID	Core level dated, cm	Lab. no.	Reported age, BP	std. dev.	corrected age *
3	0	AA-6830	1382	65	932
	79	AA-5990	8615	75	8165
	135	AA-4666	9375	70	8925
5 A	2	AA-4338	985	50	535
	28	AA-4529	5835	60	5385
	74	AA-3976	8965	110	8515
6	-	-	-	-	-
7	88	AA-4667	11575	135	11125
8	1	AA-5988	3010	50	2560
	16	AA-5989	10375	75	9925
	49	AA-4335	15025	95	14575
10 A	7	AA-6829	3210	70	2760
	22	AA-4530	9270	80	8820
	101	AA-4026	13585	110	13135
17 B	1	AA-4336	2855	80	2405
	25	AA-4531	13700	145	13250
	79	AA-4027	8755	80	8305
PO 175/1	3	AA-6847	1300	55	850
-5-1	95	AA-6849	13300	145	12850
	195	AA-7140	------	----	-----
	311	AA-6848	14845	190	14395

* 450 years subtracted for ocean water reservoir effect

Figure Captions:

Figure 1: Location map of Kangerdlugssuaq Trough.

Figure 2: Example of downcore variations in dry volume density.

Figure 3: Comparison of total calcite and opal from two cores from East Greenland shelf/slope.

East Greenland

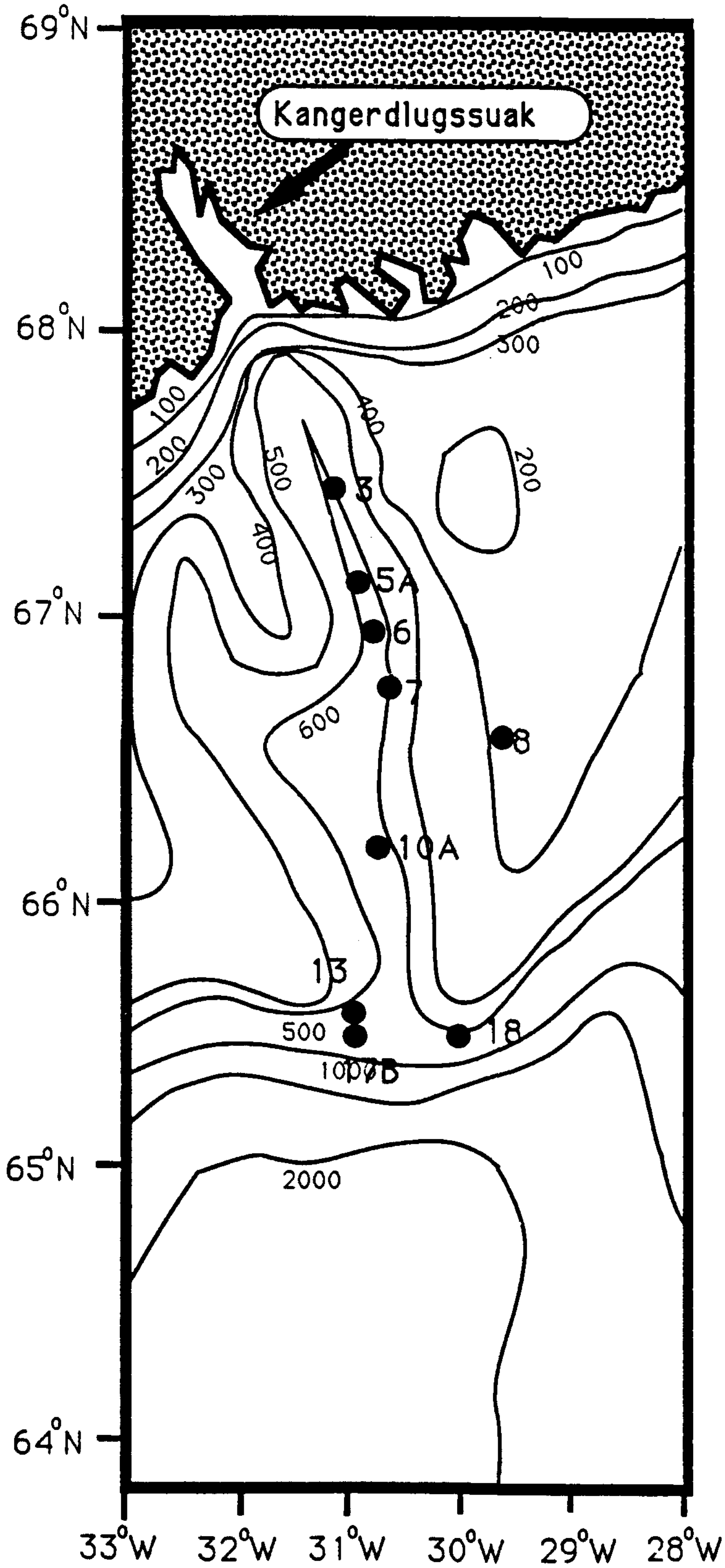


Fig. 1

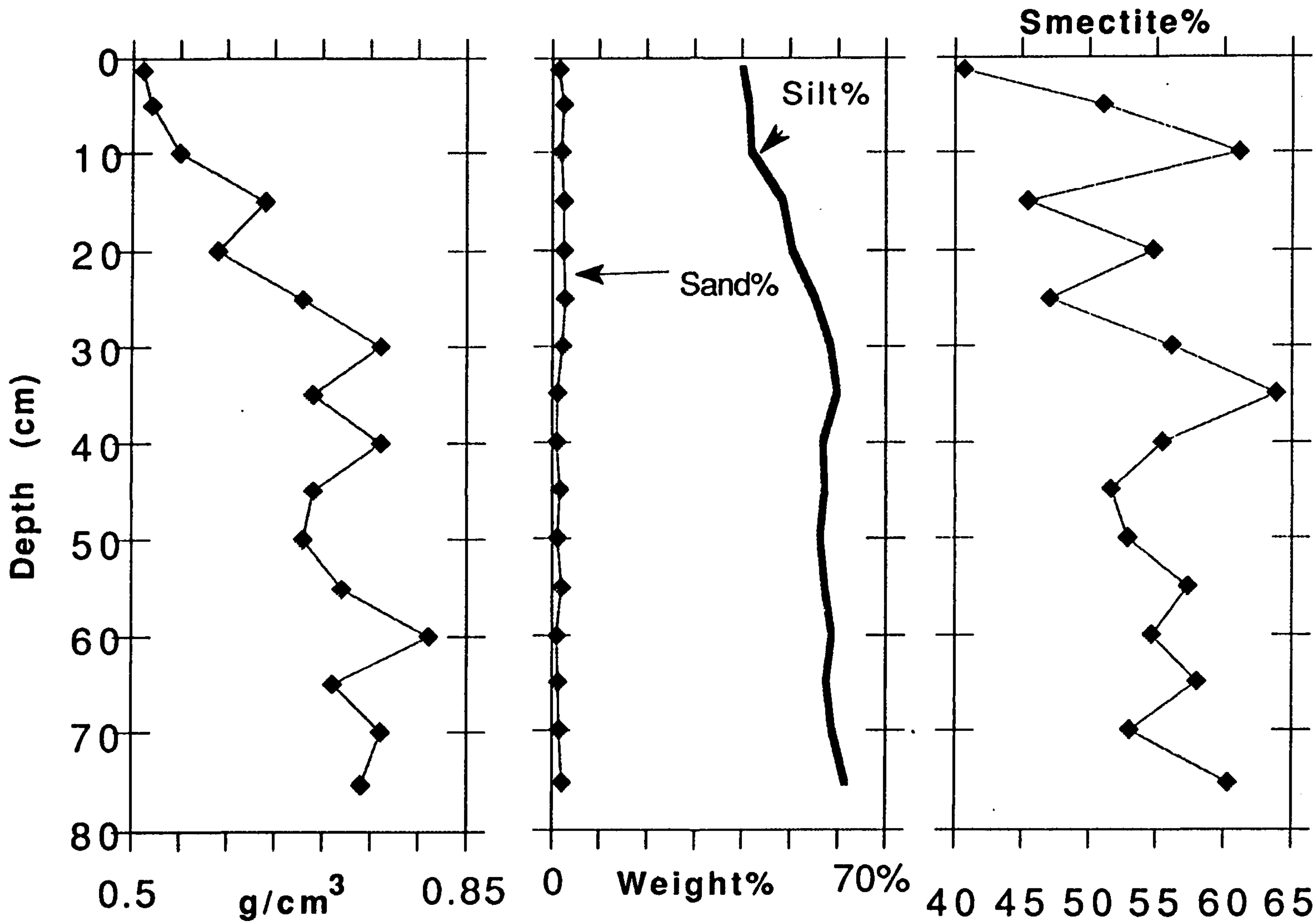
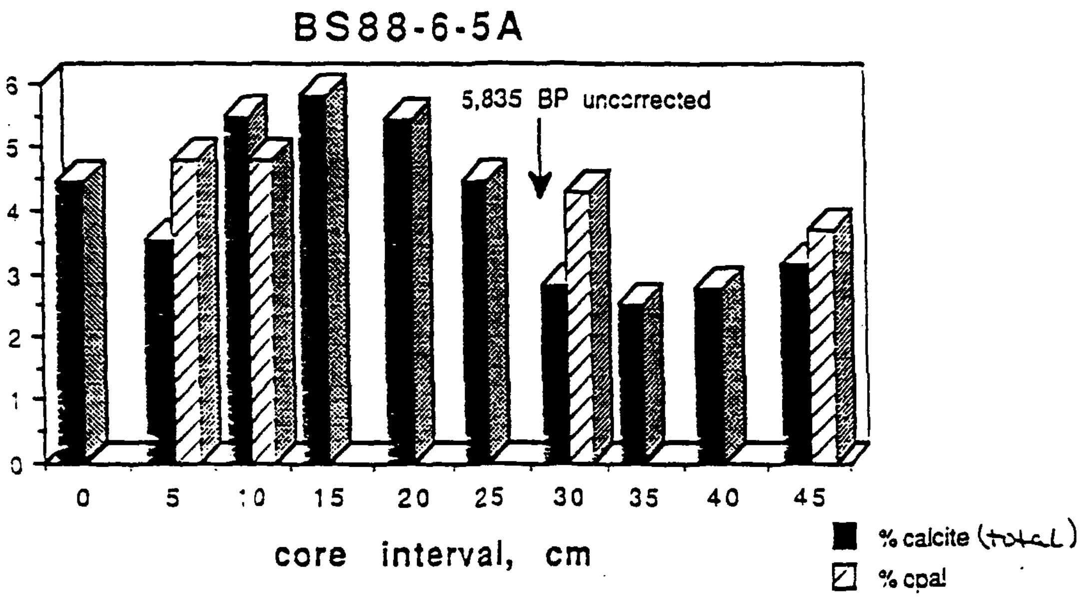

Smectite%
Silt%
Sand%
Depth (cm)
0
10
20
30
40
50
60
70
80
0.5
g/cm³
0.85
0
Weight%
70%
40 45 50 55 60 65

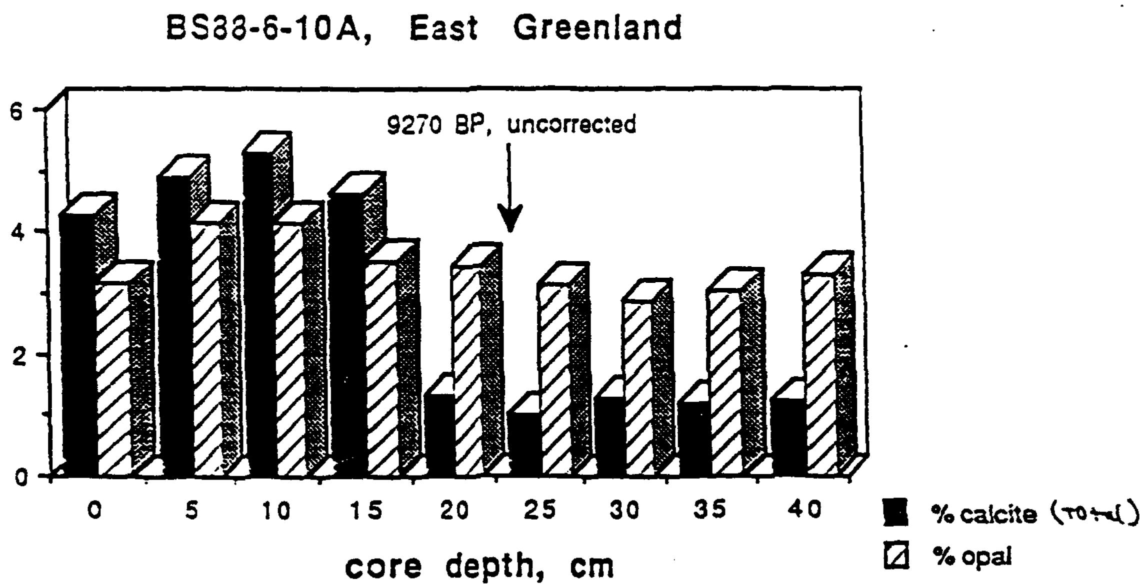
Fig. 2.

A



BS88-6-5A
5,835 BP uncorrected
0
1
2
3
4
5
6
0 5 10 15 20 25 30 35 40 45
core interval, cm
% calcite (total)
% opal

B



BS88-6-10A, East Greenland
9270 BP, uncorrected
0
2
4
6
0 5 10 15 20 25 30 35 40
core depth, cm
% calcite (total)
% opal

Fig. 3